Chuman, T., J. Sivinski, R. R. Heath, C. O. Calkins, J. H. Tumlinson, M. A. Battiste, R. L. Wydra, L. Strekowski, and J. L. Nation. 1988. Suspensolide, a new macrolide component of male Caribbean fruit-fly (Anastrepha suspensa [Loew]) volatiles. Tetrahedron Letters 29(50):6561-6564, Pergamon Press, Great Britain.

SUSPENSOLIDE, A NEW MACROLIDE COMPONENT OF MALE CARIBBEAN FRUIT FLY (ANASTREPHA SUSPENSA [LOEW]) VOLATILES[1]

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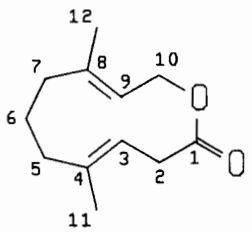
SUMMARY. A novel macrolide was isolated from volatiles produced by male Caribbean fruit flies and identified as (E,E)-4,8-dimethyl-3,8-decadien-10-olide, I, on the basis of spectroscopic and chemical evidence, including synthesis.

The Caribbean fruit fly is a pest of citrus, guava, loquat, and litchi nuts in southern Florida and the Caribbean. Males of this species produce a volatile pheromone that attracts the females. Four compounds have been isolated from extracts of male abdomens and of whole bodies, and their structures elucidated as (Z)-3-nonen-1-ol[2],(Z,Z)-3,6-nonadien-1-ol[2], anastrephin[3], II, and epianastrephin[3], III. These compounds were implicated as sex pheromone components by behavioral bioassays.



SUSPENSOLIDE

I

In a detailed investigation of the chemical communication system of this species we collected and analyzed volatiles emitted by "calling" males. In this communication, we report the identification of a novel macrolide which is a major component of the volatiles released by male Caribbean fruit flies.

Charcoal purified air was passed over calling male Caribbean fruit flies held in a glass chamber and volatiles produced by the flies were trapped on 5 cm X 1 cm (i.d.) Porapak Q filters. The volatiles were eluted from each filter with 10 ml of hexane-ether (9:1). Analysis of the volatiles by GC on a 50 m OV-101 fused silica capillary column and by capillary GC-MS indicated that several compounds were present in addition to the four previously reported pheromone components of these flies. Details of the collection and analysis of volatiles from flies of different ages and at different times during the photoperiod will be published elsewhere[4].

The major component of the volatiles was separated and purified by HPLC on a 25 X 1.25 cm (o.d.) Lichrosorb 5 μm silica column eluted with hexane-ethyl acetate (9:1).

The presence of diagnostic ions at m/z 195$(M+1)^+$ in the CI (CH_4) and at m/z 194(M^+) in the EI-MS of the isolated compound indicated that the molecular weight was 194[5]. The presence of an ester functional group in the structure was deduced from the strong IR absorption at 1732 cm^{-1}. There was no evidence of other functional groups[5]. These data indicated that the molecular formula of this compound was $C_{12}H_{18}O_2$, and that there were four degrees of unsaturation in the molecule.

In the 300 MHz PMR spectrum[5], signals at 5.01(1H,t), 4.78(1H,t), 1.47(3H,s) and 1.45(3H,s) suggested the presence of two trisubstituted double bonds, each bearing a methyl group. The absence of a terminal methyl signal in the PMR spectrum led to the assumption that this compound had a macrocyclic structure. Thus, the four unsaturations deduced from the molecular formula were assigned to the ester group, the two double bonds and the cyclic structure.

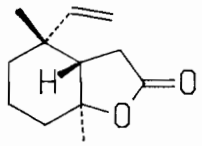
Decoupled and coupled-with-NOE CMR spectra[5] obtained with about 3 mg of natural compound indicated the presence of 12 carbons which were assigned to two methyls [15.37($\underline{C}H_3$-C=CH- x 2)], five methylenes [25.95(-$\underline{C}H_2$-), 36.01(-$\underline{C}H_2$-CO-), 41.87(-$\underline{C}H_2$- x 2), and 61.35(-$\underline{C}H_2$-O-)], two methines [116.64(-$\underline{C}$H=), 120(-$\underline{C}$H=)], two quarternary carbons [142.13(-$\underline{C}(CH_3)$=), 144.08(-$\underline{C}(CH_3)$=)] and an ester carbonyl carbon [169.54(-$\underline{C}$OO-)]. Proton-proton decoupling PMR and carbon-proton selective decoupling CMR measurements indicated that the PMR signal at 4.5(2H,-$C\underline{H}_2$-O-), which was coupled with the methylene carbon signal at 61.35, was also coupled with the PMR signal at 5.01(1H, =C$\underline{H}$-). The PMR signal at 2.7(2H,-$C\underline{H}_2$-CO-) was coupled with the methylene carbon signal at 36.01, and with the PMR signal at 4.78(1H,=C$\underline{H}$-). Therefore two partial structures, -$C(CH_3)$=CH-CH_2-CO- and -$C(CH_3)$=CH-CH_2-O-, could be constructed from the above data. Only one possible structure, 4,8-dimethyl-3,8-decadien-1-olide, could be constructed to incorporate the remaining three methylenes and the above two partial structures.

The chemical shift values of the two methyl signals in the decoupled CMR suggested that the geometrical configuration of both double bonds, C3-C4 and C8-C9, was $\underline{E}$[6].

The position of the two double bonds was confirmed by micro-ozonolysis of the isolated compound. The CI(CH_4)-MS and EI-MS[7] indicated that the structure of the ozonolysis product was 2,6-heptadione, formed by cleavage of the C3-C4 and C8-C9 double bonds in the macrolide molecule.

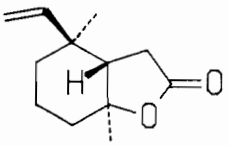
From all the above data, we determined the structure of the isolated compound to be (E,E)-4,8-dimethyl-3,8-decadien-10-olide, I, for which we suggest the name suspensolide. It is interesting to note that I differs only in the position of one double bond from a pheromone, (E,E)-4,8-dimethyl-4,8-decadien-10-olide, isolated from the rusty grain beetle by Wong et al[6].

The assigned structure of I was confirmed by synthesis[8]. Synthetic and natural suspensolide are spectroscopically (IR, PMR, CMR, EI-MS, and CI-MS) and chromatographically (GC, 50 m OV-101 and Carbowax 20M capillary columns) identical. The biological activity of suspensolide is being investigated.



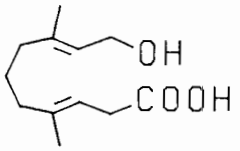
ANASTREPHIN

II



EPIANASTREPHIN

III



4,8-DIMETHYL-10-HYDROXY-3,8-DECADIENOIC ACID

IV

The fact that GC of suspensolide, I, resulted in partial decomposition to furnish anastrephin, II, and epianastrephin, III, indicates the close relationship in structure between suspensolide and the anastrephins. It is possible that suspensolide is a precursor for the anastrephins or that a precursor, like (E,E)-4,8-dimethyl-10-hydroxy-3,8-decadienoic acid[9], IV, exists for both suspensolide and the anastrephins.

Notes and References

(1) (a) Presented in part at the Sixth International Congress of Pesticide Chemistry (IUPAC), Ottawa, Canada, August 10-15, 1986; Abstract 2C-03. (b) This article reports the results of research only. Mention of a proprietary product does not constitute an endorsement or the recommendation for its use by USDA.

(2) J. L. Nation, Environ. Entomol., 4, 27 (1975).

(3) a) M. A. Battiste, L. Strekowski, D. P. Vanderbilt, M. Visnick, R. W. King, and J. L. Nation, Tetrahedron Lett., 24, 2611 (1983).
b) J. B. Stokes, E. C. Uebel, J. D. Warthern, Jr., M. Jacobson, J. L. Flippen-Anderson, R. Gilardi, L. M. Spishakoff, and K. R. Wilzer, J. Agric. & Food Chem., 31. 1162 (1983).

(4) We propose to publish the detailed analysis of the volatiles in J. Chem. Ecology.

(5) (EI-MS, m/z: 41(100), 43(12), 53(40), 55(26), 67(78), 68(35), 79(37), 81(55), 93(21), 95(17), 96(67), 107(16), 121(8), 135(4), 152(0.5), 166(0.7), 179(0.8), 194(4.4).
FT-IR (cm^{-1}): on KBr, 2926(s), 2893(s), 1732(s), 1457(m), 1436(m), 1386(m), 1334(m), 1251(m), 1231(m), 1199(m), 1120(m), 1108(m), 932(m); in $CHCl_3$, 2935(s), 2926(s), 2861(s), 1724(s), 1457(m), 1439(m), 1386(m), 1335(m), 1256(m), 1121(m), 1112(m), 966(m), 935(m), 918(m).
PMR (C_6D_6, TMS): 2.7(2H,m, C(2)$\underline{H}_2$); 4.78(1H,t,J=7.9Hz, C(3)$\underline{H}$); 1.9(4H,m, C(5)$\underline{H}_2$ and C(7)$\underline{H}_2$); 1.3(2H,m, C(6)$\underline{H}_2$); 5.01(1H,t,J=8.2Hz, C(9)$\underline{H}$); 4.5(2H,brdm, C(10)$\underline{H}_2$); 1.45(3H,s, C(11) or (12)$\underline{H}_3$); 1.47(3H,s, C(11) or (12)$\underline{H}_3$).
CMR (C_6D_6, TMS): 169.54 (s, C(1)); 36.01(t,J=134.0Hz, C(2)); 120.72(d,J=158.7Hz, C(3) or (9)); 144.08(s, C(4) or (8)); 41.87(t,J=124.5Hz, C(5) & (7); 25.95(t,J=125.7Hz, C(6)); 142.13(s, C(4) or (8)); 116.64(d,J=156.3Hz, C(3) or (9)); 61.35(t,J=147.5Hz, C(10)); 15.37(q,J=134.3Hz, C(11) &(12)).
The above proton and carbon assignments are based on decoupling experiments.

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b) A. Ohkubo, H. Kawai, T. Matsunaga, T. Chuman, S. Yamazaki, and S. Toda, Tetrahedron Lett., 21, 4095 (1980).
c) J. W. Wong, V. Verigin, A. C. Oehlshlager, J. H. Borden, H. D. Pierce, Jr., A. M. Pierce and L. Chong, J. Chem. Ecol., 9, 451 (1983).

(7) EI-MS, m/z; 43(100), 55(6), 58(22), 71(17), 85(9), 111(2), 128(M^+,4). CI-MS: 129(M+1).

(8) See the following communication for synthetic procedure and additional supporting spectral results.

(9) A. Saito, H. Matsushita, and H. Kaneko, Chem. Lett., 729 (1984).

(Received in USA 8 July 1987)